US009425695B2

(12) **United States Patent**
Shinohara et al.

(10) **Patent No.: US 9,425,695 B2**
(45) **Date of Patent: Aug. 23, 2016**

(54) **DC-DC CONVERTER**

(71) Applicant: **Hitachi Automotive Systems, Ltd.**, Hitachinaka-shi, Ibaraki (JP)

(72) Inventors: **Hidenori Shinohara**, Hitachinaka (JP); **Tatsuya Nakazawa**, Yokohama (JP); **Keisuke Fukumasu**, Tokyo (JP); **Yoshiharu Yamashita**, Hitachinaka (JP)

(73) Assignee: **Hitachi Automotive Systems, Ltd.**, Hitachinaka-shi (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/419,067**

(22) PCT Filed: **Jun. 28, 2013**

(86) PCT No.: **PCT/JP2013/067763**

§ 371 (c)(1),
(2) Date: **Feb. 2, 2015**

(87) PCT Pub. No.: **WO2014/021035**

PCT Pub. Date: **Feb. 6, 2014**

(65) **Prior Publication Data**

US 2015/0194898 A1 Jul. 9, 2015

(30) **Foreign Application Priority Data**

Aug. 3, 2012 (JP) 2012-172468

(51) **Int. Cl.**
H02M 3/335 (2006.01)
H05K 9/00 (2006.01)
H05K 7/20 (2006.01)
H02M 1/44 (2007.01)

(52) **U.S. Cl.**
CPC ***H02M 3/33507*** (2013.01); ***H05K 7/20927*** (2013.01); ***H05K 9/0037*** (2013.01); *H02M 1/44* (2013.01); *H02M 3/33576* (2013.01)

(58) **Field of Classification Search**
CPC ... H05K 9/0037; H05K 7/20927; H02M 1/44; H02M 3/33507; H01R 13/68
USPC 363/17; 361/623
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,169,780 B2 * 5/2012 Yoshino H05K 7/20927 165/104.33

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2000-324839 A 11/2000
JP 2008-125283 A 5/2008

(Continued)

OTHER PUBLICATIONS

International Search Report (PCT/ISA/210) dated Oct. 8, 2013 with English translation (five pages).

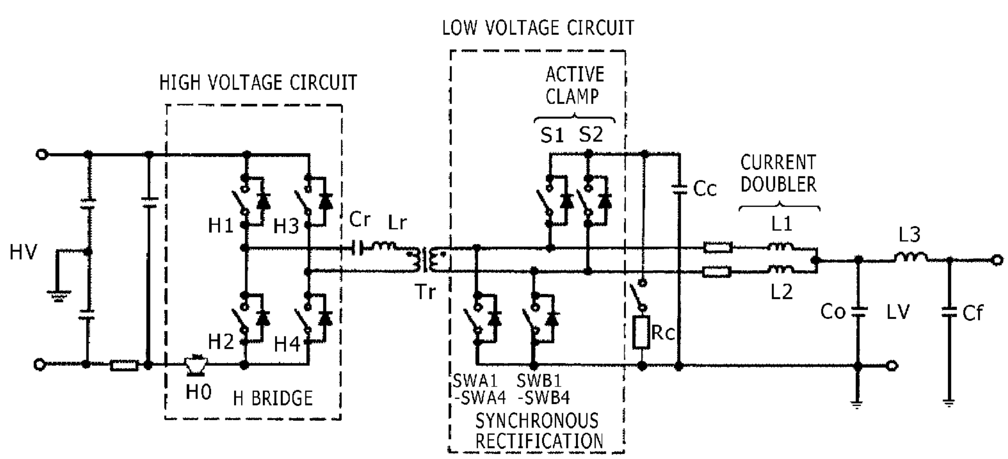
(Continued)

Primary Examiner — Adolf Berhane
Assistant Examiner — Afework Demisse
(74) *Attorney, Agent, or Firm* — Crowell & Moring LLP

(57) **ABSTRACT**

There is provided a device in which superimposition of noise radiated from a circuit is reduced, and a noise reducing effect of a filter is ensured. A DC-DC converter according to the present invention includes a transformer, a high voltage-side switching circuit section, a low voltage-side switching circuit section, a noise filter circuit section electrically disposed between the low voltage-side switching circuit section and the low voltage-side circuit section, a metallic case that houses the transformer, the high voltage-side switching circuit section, the low voltage-side switching circuit section, and the noise filter circuit section, a drive circuit board having a drive circuit that drives the low voltage-side switching circuit section, and a metallic base board having the drive circuit board mounted thereon. The case has a metallic partition wall connected to the case. The partition wall is disposed between the low voltage-side switching circuit section and the noise filter circuit section. The partition wall is connected to the base board.

5 Claims, 13 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2009/0073335	A1 *	3/2009	Yagi	G02F 1/133707 349/39
2010/0321889	A1	12/2010	Yoshino et al.	
2013/0094269	A1 *	4/2013	Maeda	H02M 7/003 363/141

FOREIGN PATENT DOCUMENTS

JP	2009-284701	A	12/2009
JP	2010-245232	A	10/2010
JP	2011-4520	A	1/2011
JP	2011-139602	A	7/2011
WO	WO 2011/125781	A1	10/2011

OTHER PUBLICATIONS

Japanese Office Action issued in counterpart Japanese Application No. 2012-172468 dated May 12, 2015, with English translation (five (5) pages).

* cited by examiner

FIG. 1

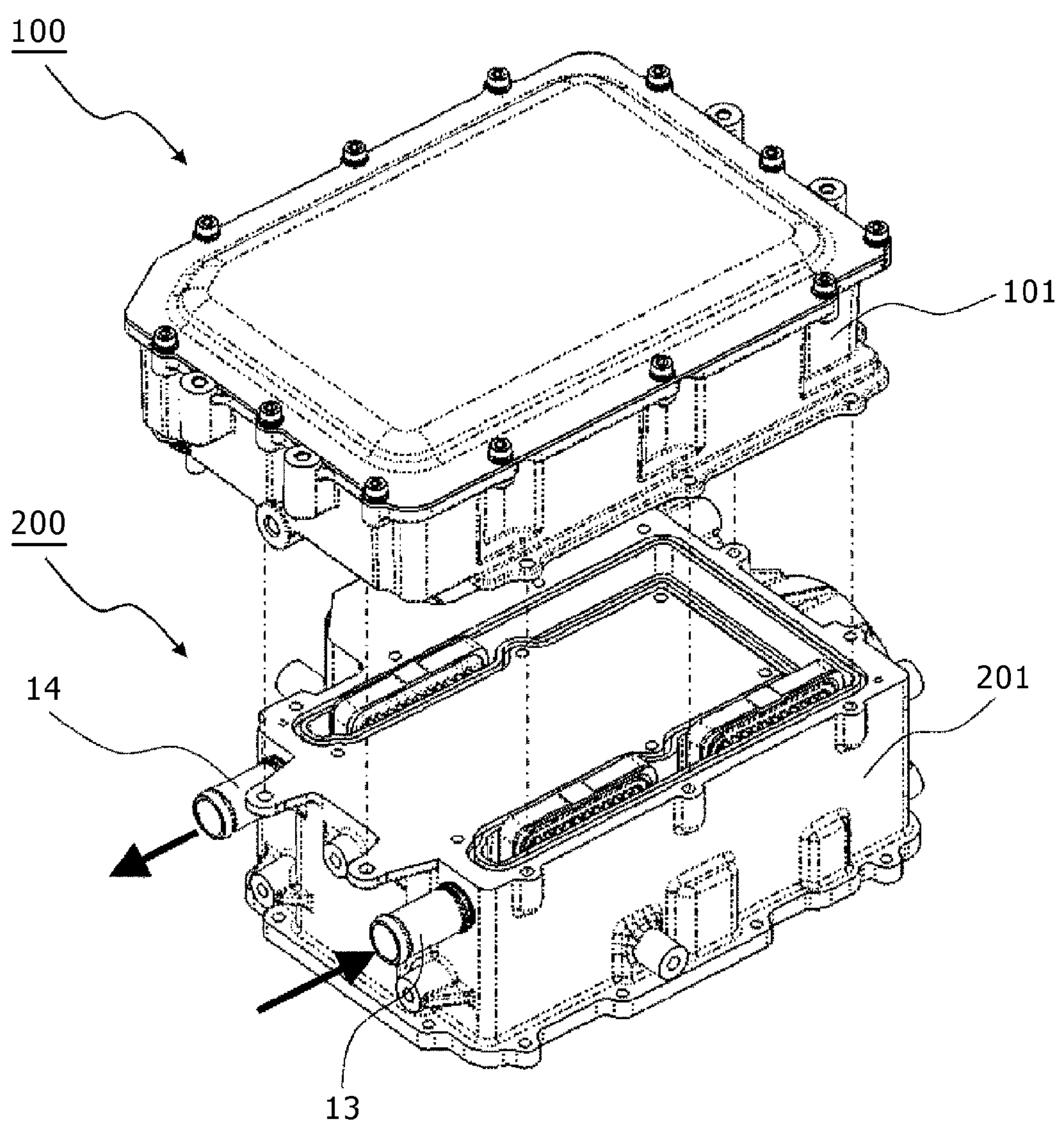


FIG. 2

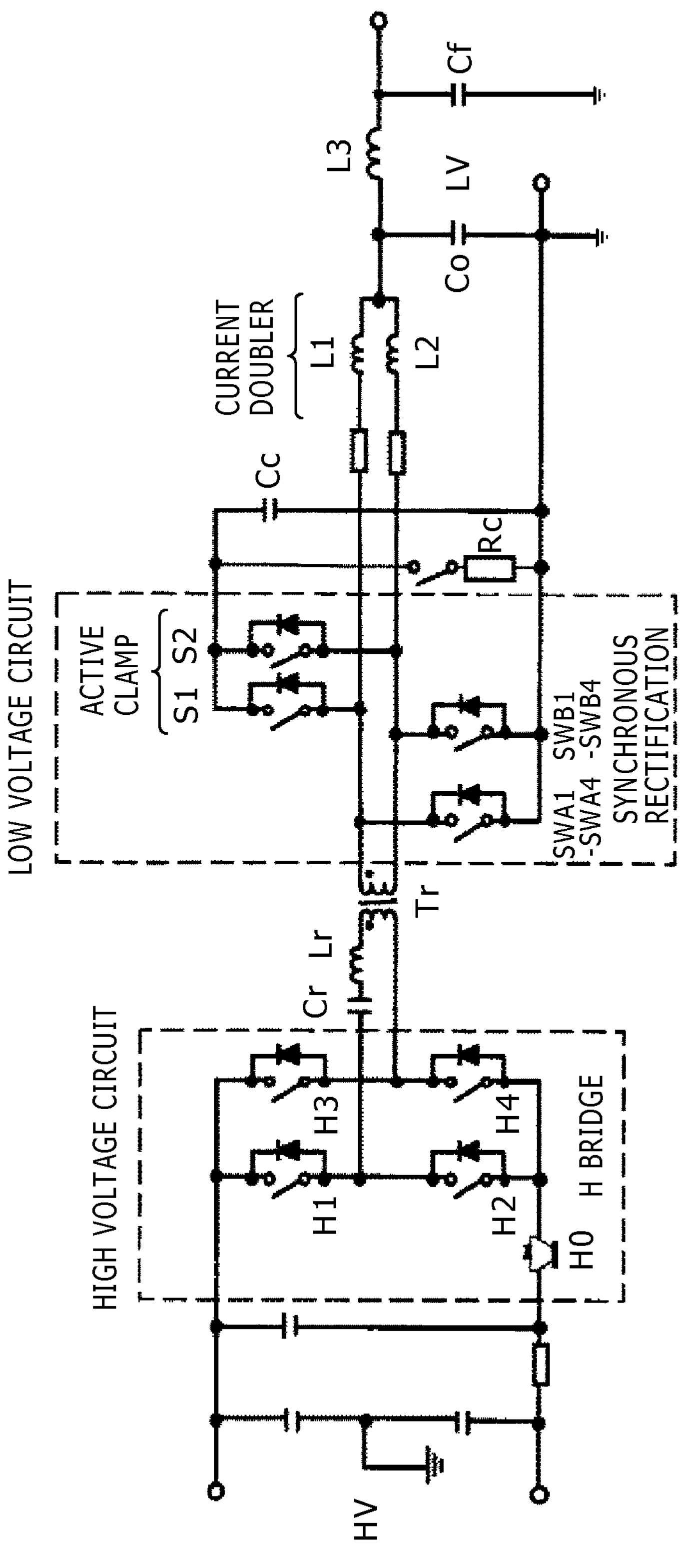

HIGH VOLTAGE CIRCUIT
H BRIDGE
H0
H1
H2
H3
H4
HV
Cr
Lr
Tr
LOW VOLTAGE CIRCUIT
ACTIVE CLAMP
S1
S2
SWA1 -SWA4
SWB1 -SWB4
SYNCHRONOUS RECTIFICATION
Rc
Cc
CURRENT DOUBLER
L1
L2
Co
LV
L3
Cf

FIG.3(a)

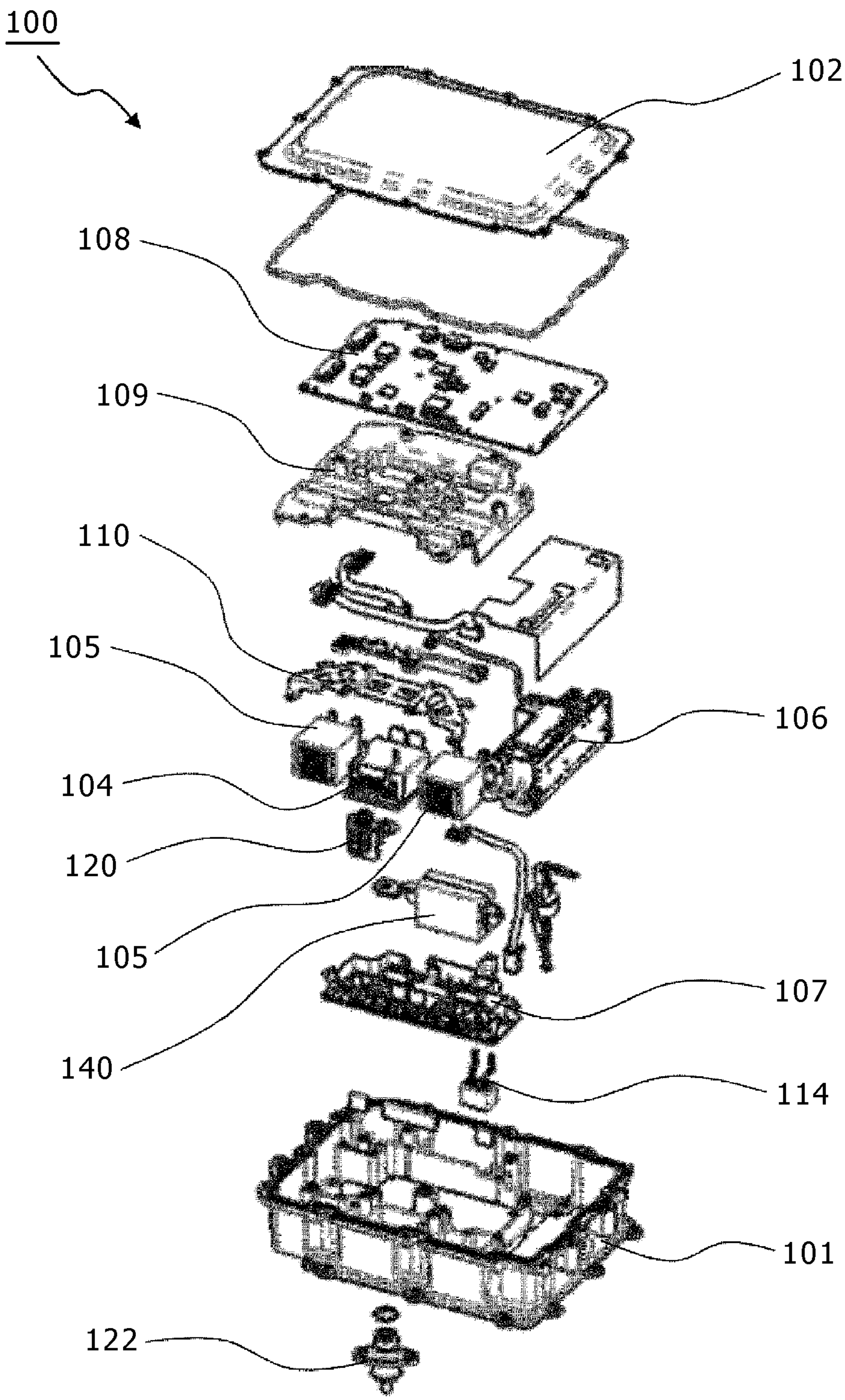


FIG.3(b)

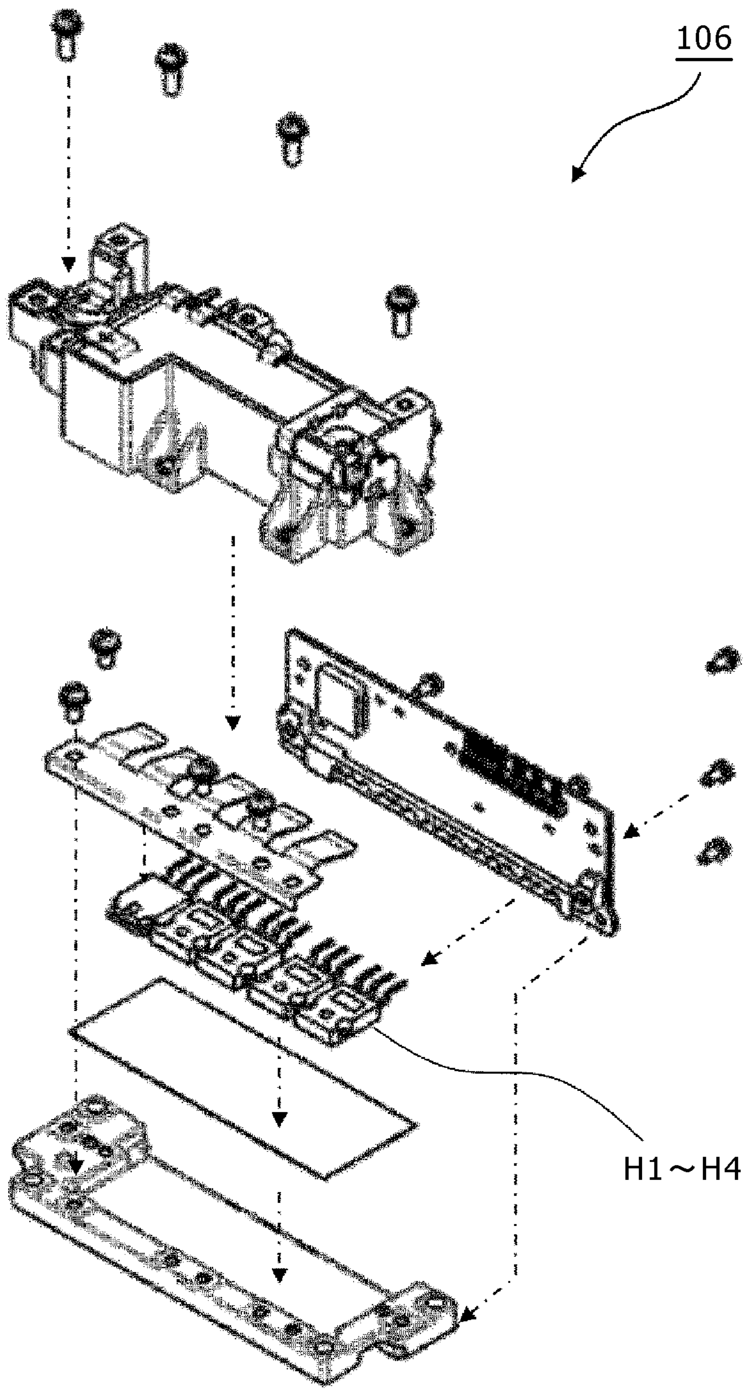


FIG.4(a)

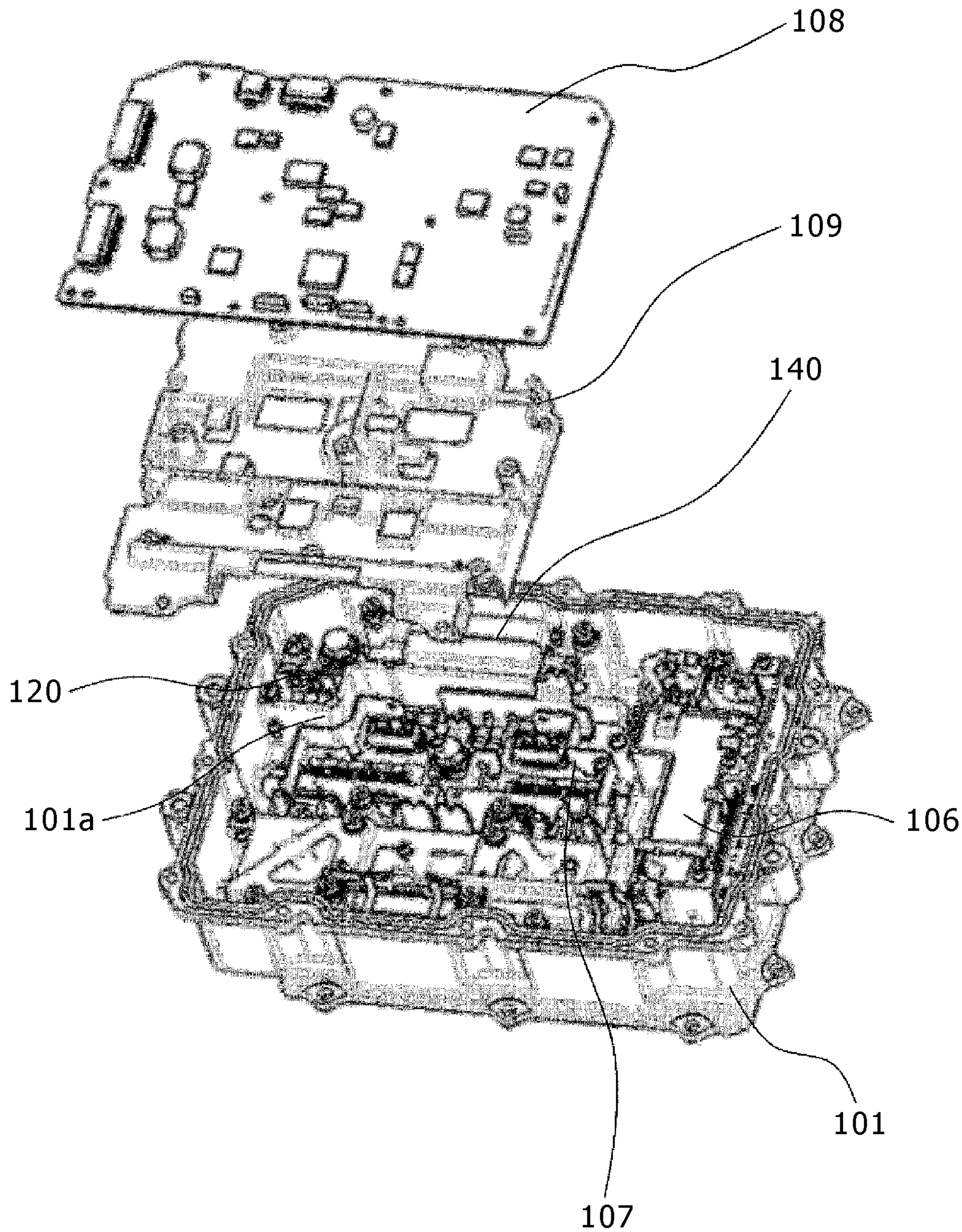


FIG.4(b)

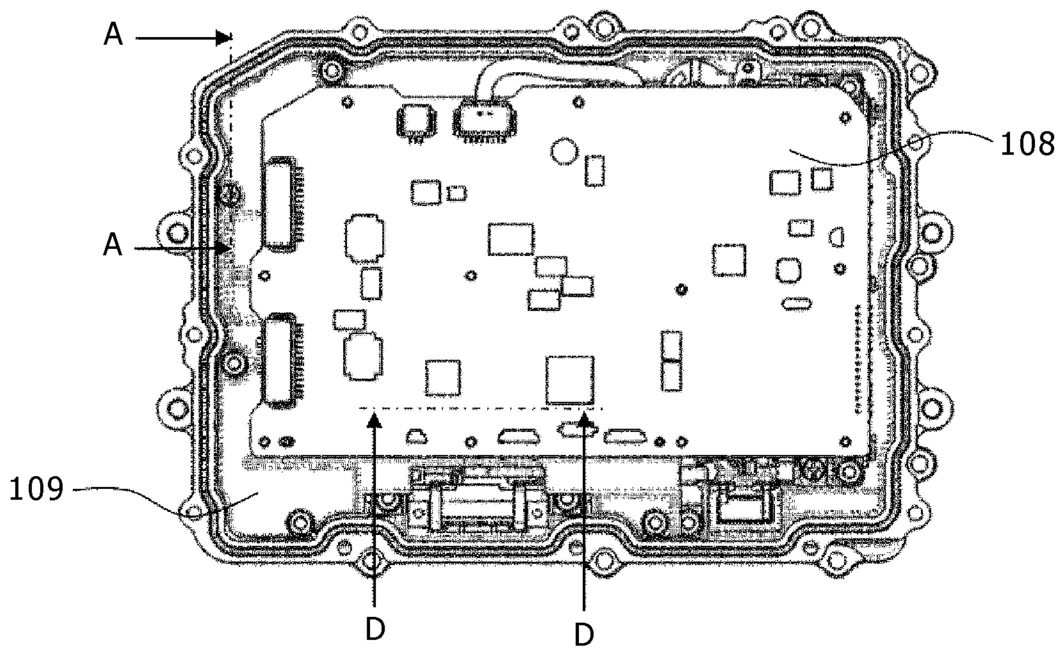


FIG.4(c)

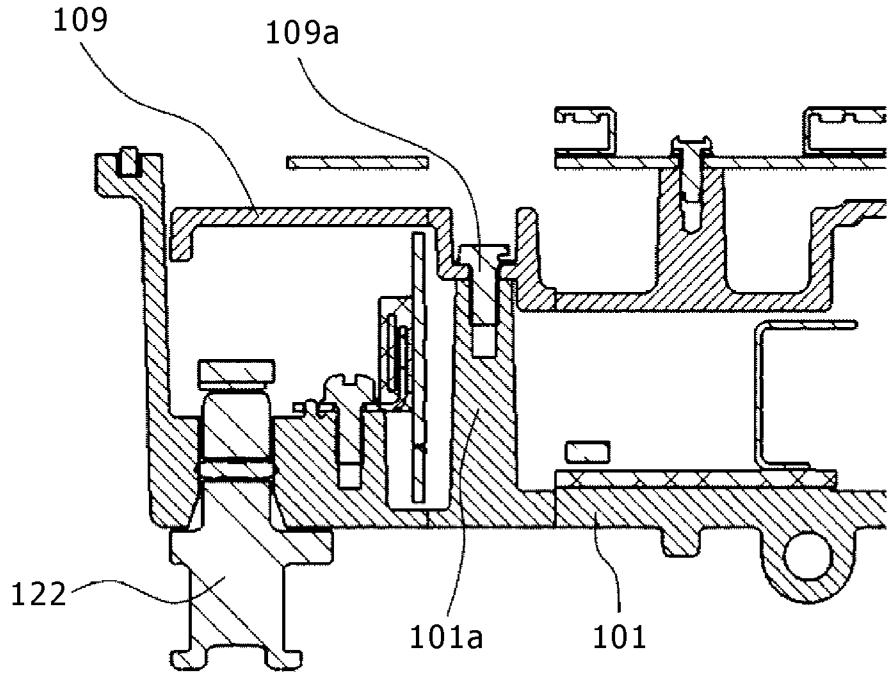


FIG. 5

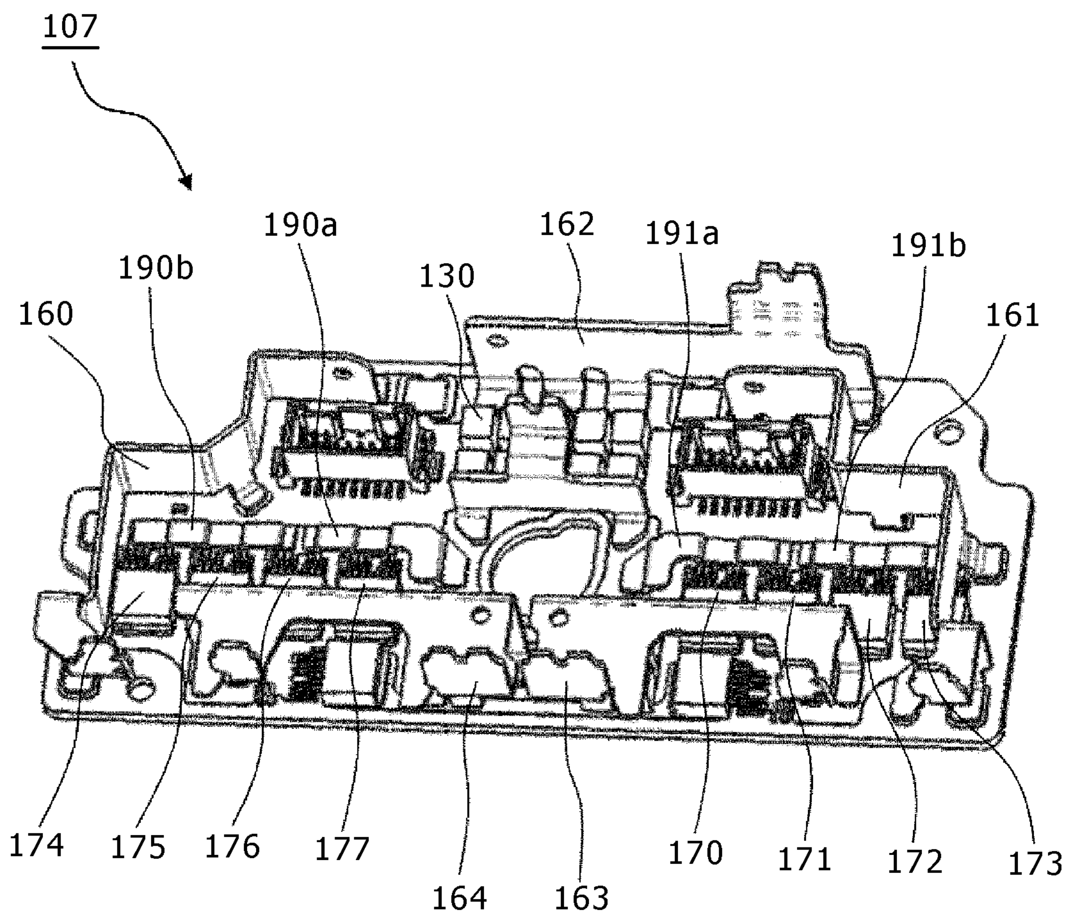

107
160
190b
190a
130
162
191a
191b
161
174
175
176
177
164
163
170
171
172
173

FIG.6(a)

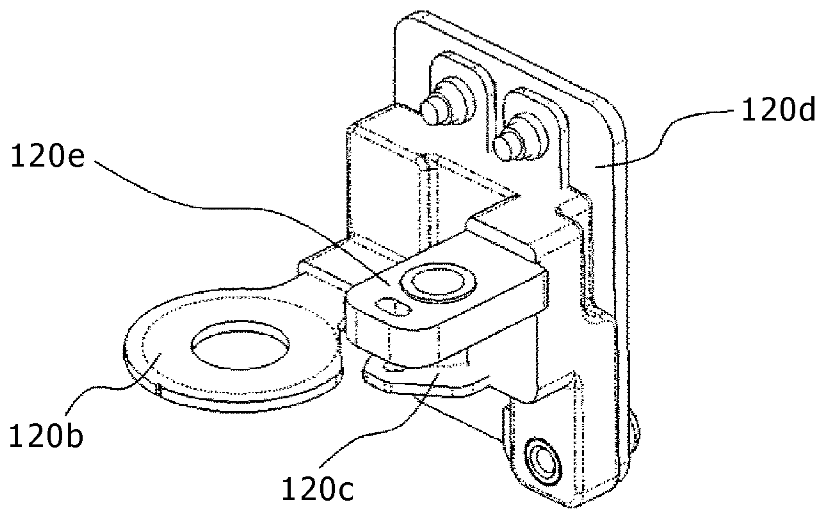


FIG.6(b)

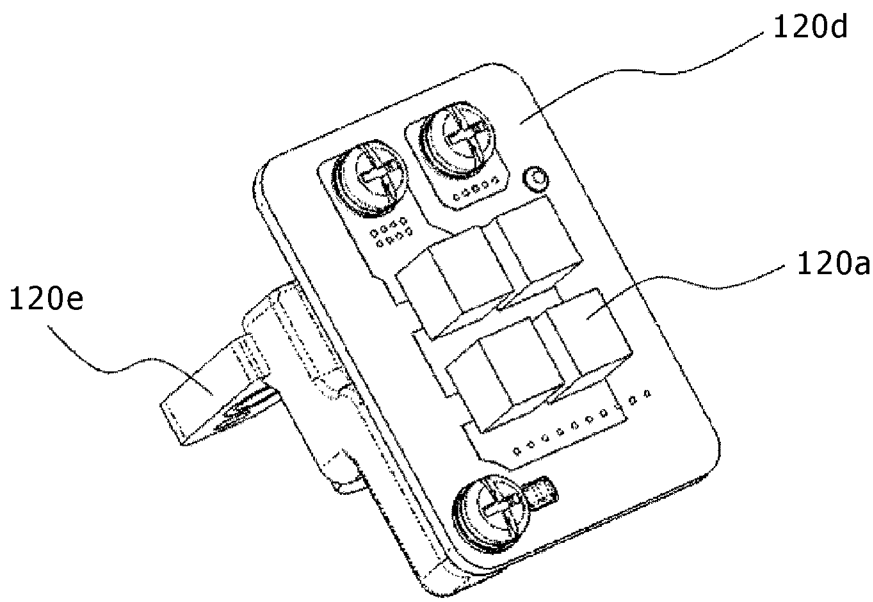
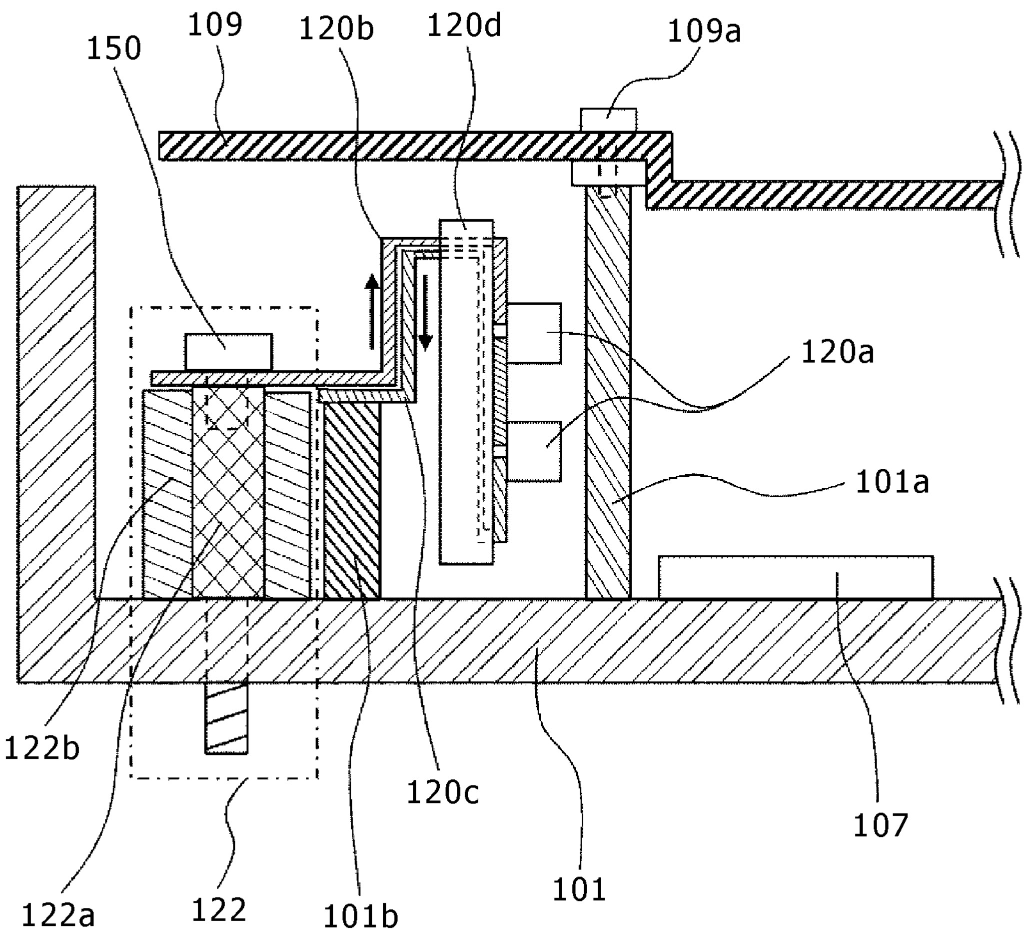


FIG. 7



109
120b
120d
109a
150
120a
101a
122b
120c
107
101
122a
122
101b

FIG.8(a)

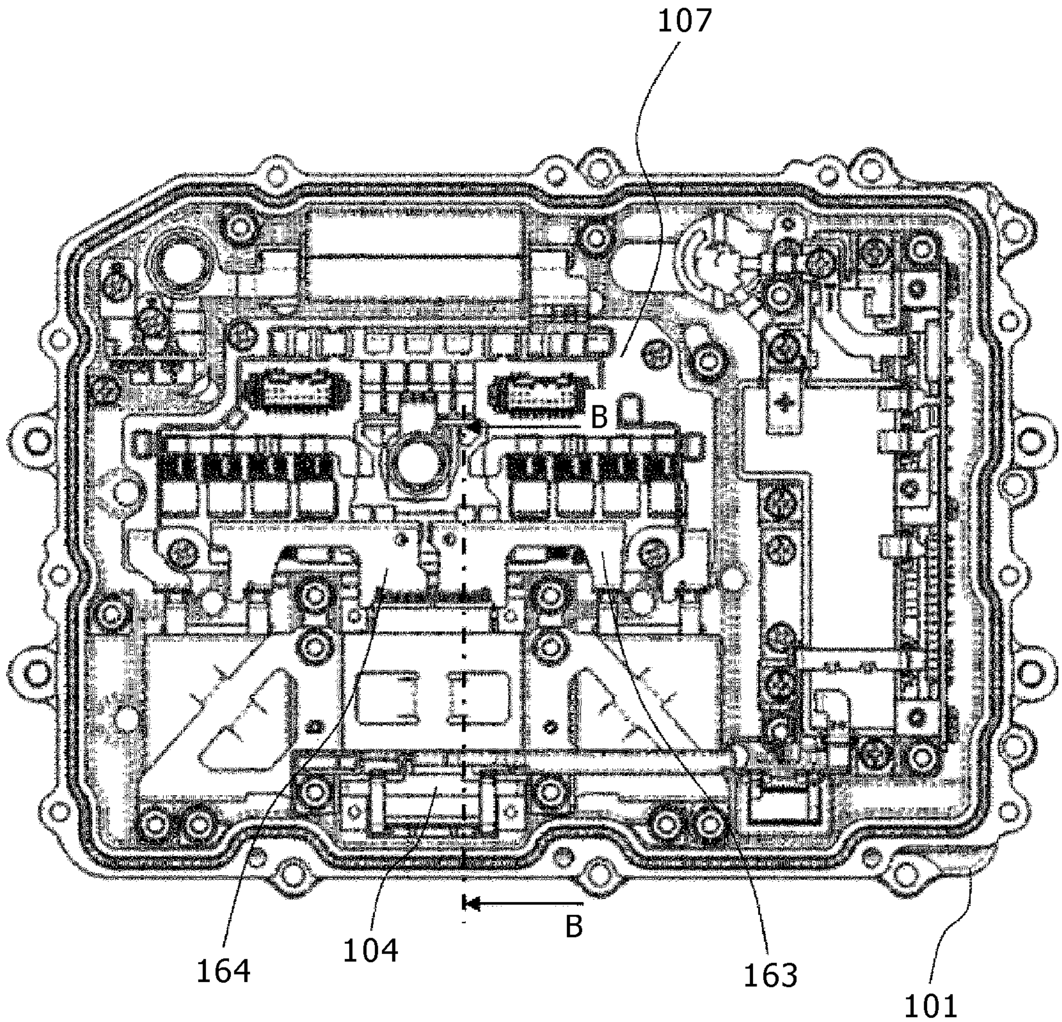


FIG. 8(b)

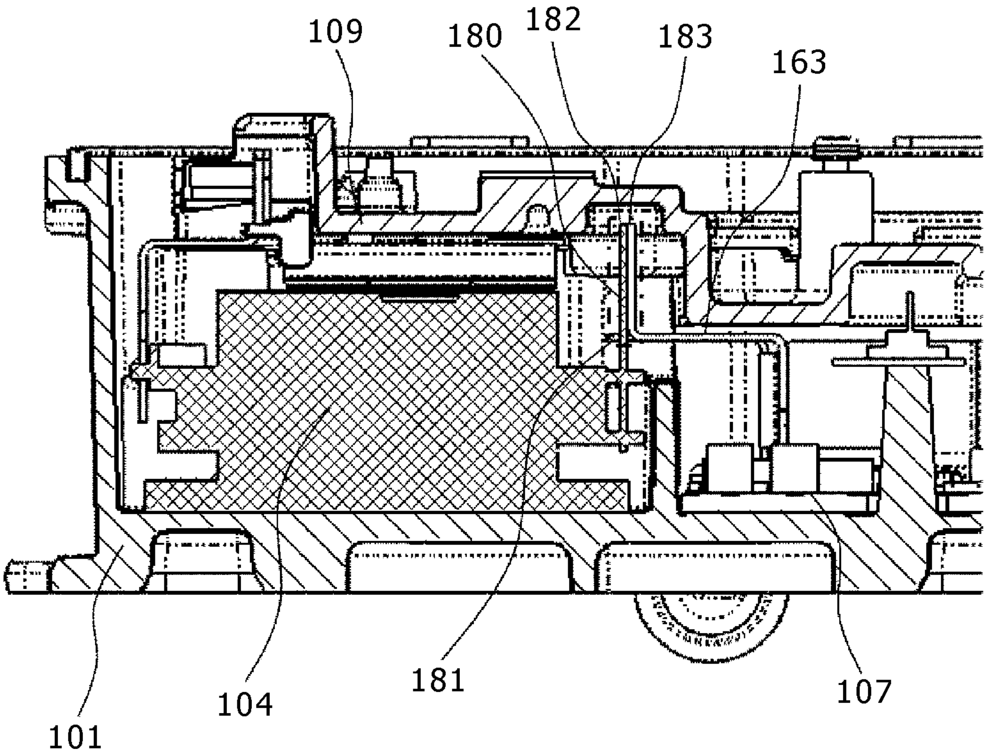


FIG.9(a)

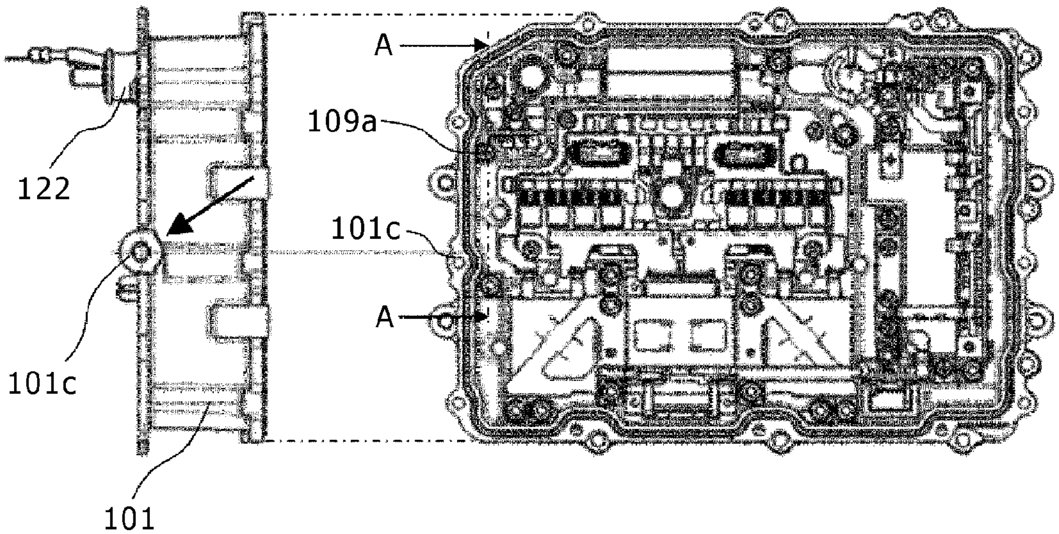


FIG.9(b)

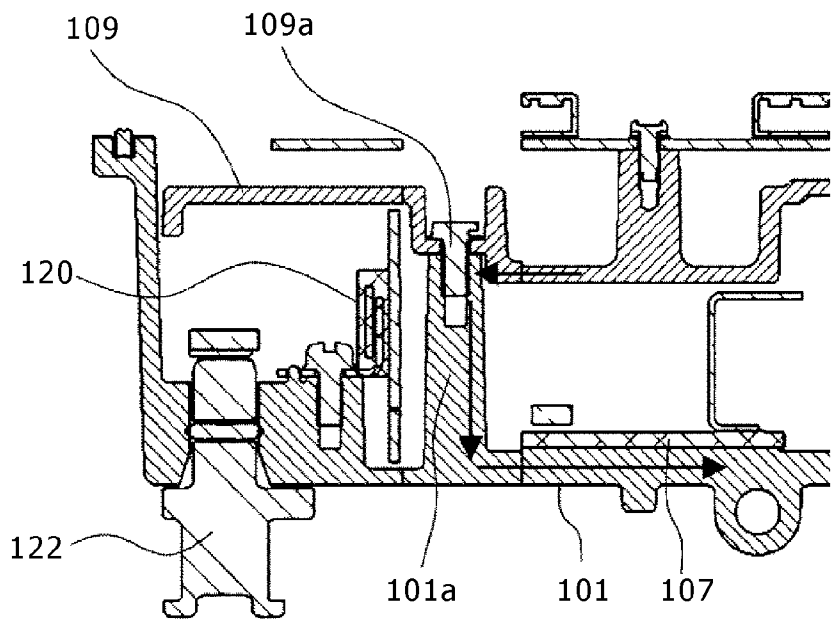
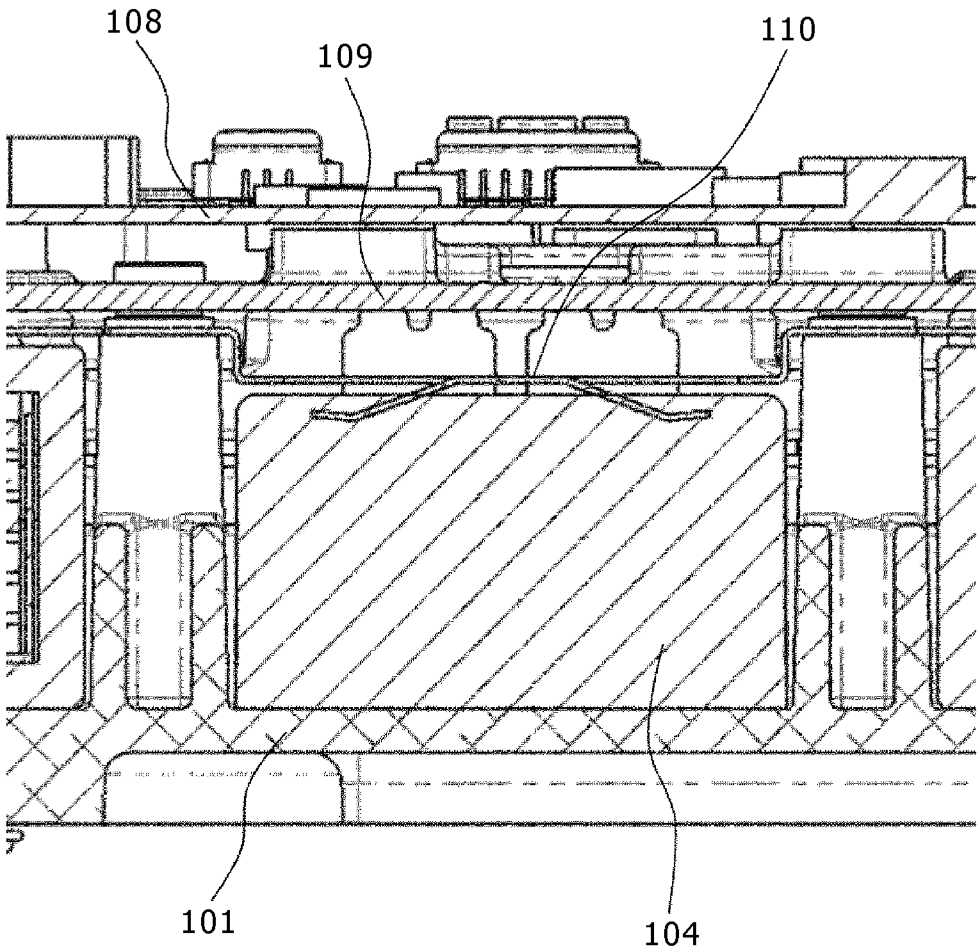


FIG.10



DC-DC CONVERTER

TECHNICAL FIELD

The present invention relates to a DC-DC converter device, and more specifically, to a DC-DC converter device especially applied to the electric automobile and the plug-in hybrid vehicle.

BACKGROUND ART

A high voltage storage battery and a low voltage storage battery are mounted on the electric automobile or the plug-in hybrid vehicle. The high voltage storage battery is used as a power drive for driving the motor via an inverter device, and the low voltage storage battery is used for activating the accessory such as a light and a radio of the vehicle.

The vehicle of the above type has a DC-DC converter device for power conversion from the high voltage storage battery to the low voltage storage battery, or from the low voltage storage battery to the high voltage storage battery.

In the filter circuit connected to the power conversion device, the noise radiated from the power conversion circuit, which propagates through the space, and the electromagnetic noise generated by the eddy current flowing in the housing maybe superimposed on the filter circuit to cause the risk of deteriorating filter performance.

Patent Literature 1 discloses the known means for solving the aforementioned problem, only proposing the case having a metallic base section to which the ground potential is applied. The aforementioned related art still has the problem that the noise owing to the noise current superimposed on the base section is not taken into consideration.

It is demanded that the aforementioned DC-DC converter device should lessen the influence resulting from radiation of the electromagnetic noise generated in the device.

CITATION LIST

Patent Literature

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2000-324839

SUMMARY OF INVENTION

Technical Problem

It is an object of the present invention to provide a device for reducing superimposition of the noise radiated from the circuit to ensure the filter noise reduction effect.

Solution to Problem

The DC-DC converter according to the present invention includes a transformer, a high voltage-side switching circuit section electrically disposed between the transformer and a high voltage-side circuit section, a low voltage-side switching circuit section electrically disposed between the transformer and a low voltage-side circuit section, a noise filter circuit section electrically disposed between the low voltage-side switching circuit section and the low voltage-side circuit section, a metallic case that houses the transformer, the high voltage-side switching circuit section, the low voltage-side switching circuit section, and the noise filter circuit section, a drive circuit board having a drive circuit that drives the low voltage-side switching circuit section, and a metallic base

board having the drive circuit board mounted thereon. The case is disposed between the low-voltage switching circuit section and the noise filter circuit section, and has a metallic partition wall connected to the case. The base board is disposed at a position opposite a bottom surface of the case, which interpose the low-voltage switching circuit section. The partition wall is connected to the base board.

Advantageous Effects of Invention

The present invention ensures to lessen the influence of the noise current on the filter circuit section.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagrammatic perspective view for explaining a power converter.

FIG. **2** is a view representing a circuit structure of a DC-DC converter device **100**.

FIG. **3**(*a*) is an exploded perspective view for explaining the component arrangement in the DC-DC converter device **100**.

FIG. **3**(*b*) is an exploded perspective view of a high voltage circuit **106**.

FIG. **4**(*a*) is an exploded perspective view for explaining an inner structure of the DC-DC converter device **100**.

FIG. **4**(*b*) is a plan view representing an inner section of the DC-DC converter device **100**.

FIG. **4**(*c*) is a sectional view taken along line A-A of FIG. **4**(*b*), which is seen from an arrow direction.

FIG. **5** is a perspective view representing a low voltage substrate **107** in the DC-DC converter device **100**.

FIG. **6**(*a*) is a perspective view representing a filter substrate **120** in the DC-DC converter device **100**.

FIG. **6**(*b*) is a perspective view representing the filter substrate **120** in the DC-DC converter device **100**, when seen from the direction different from the one shown in FIG. **6**(*a*).

FIG. **7** is a schematic sectional view for explaining the structure around the filter substrate **120** in the DC-DC converter device **100**.

FIG. **8**(*a*) is a plan view showing the inside of the DC-DC converter device **100** (as an explanatory view of a connection state between bus bars **163**, **164** and a main transformer **104**).

FIG. **8**(*b*) is a sectional view taken along line B-B of FIG. **8**(*a*) when seen from the arrow direction.

FIG. **9**(*a*) is a plan view showing the inside of the DC-DC converter device **100** (as an explanatory view of an arrangement of a connection section **109***a*, the filter circuit **120**, and the ground with respect to a ground terminal **101***c*).

FIG. **9**(*b*) is a sectional view taken along line A-A of FIG. **9**(*a*) when seen from the arrow direction.

FIG. **10** is a sectional view taken along line D-D of FIG. **4**(*b*) when seen from the arrow direction.

DESCRIPTION OF EMBODIMENT

An embodiment for carrying out the present invention will be described referring to the drawings.

FIG. **1** is a perspective view showing an outline of a power converter. The power converter is formed by integrating the DC-DC converter device **100** and an inverter device **200**. FIG. **1** shows the DC-DC converter device **100** and the inverter device **200** which are separated. The DC-DC converter device **100** is fixed to a bottom surface of a case of the inverter device **200** with a plurality of bolts (not shown).

The power converter is applied to the electric automobile. The inverter device **200** serves to drive the traction motor by the power from the onboard high voltage storage battery. The low voltage storage battery is mounted on the vehicle for activating the accessary such as the light and radio. The DC-DC converter device **100** carries out power conversion from the high voltage storage battery to the low voltage storage battery, or from the low voltage storage battery to the high voltage storage battery.

A refrigerant flow passage through which the refrigerant flows is formed in the side wall of a case **201** of the inverter device **200**. The refrigerant flows into the flow passage from an inlet pipe **13**, and flows out from an outlet pipe **14**. Meanwhile, a case **101** of the DC-DC converter device **100** is fixed to the opposite bottom surface of the inverter device **200** without leaving any gap therebetween. In the fixed state, the DC-DC converter device **100** is allowed to share the refrigerant flow passage. In this embodiment, generally, water is suitable as the refrigerant. However, the refrigerant of any other type may be employed.

The DC-DC converter device **100** will be described. FIG. **2** is a view showing a circuit structure of the DC-DC converter device **100**. As FIG. **2** shows, the DC-DC converter device **100** according to this embodiment is configured to carry out bilateral DC-DC conversion for converting the voltage between the low voltage storage battery and the high voltage storage battery. The high voltage circuit is configured as an H bridge circuit, and the low voltage circuit is configured to have a synchronous rectification circuit and an active clamp circuit. Efforts have been made to employ the large current component for the switching element and enlarge the smoothing choke coil so as to realize the high output through the bilateral DC-DC conversion.

More specifically, the H bridge type switching circuit structure (H**1** to H**4**) is provided at the high voltage side, which uses MOSFET with reflux diode. The switching control is conducted through zero voltage switching at the high switching frequency (100 kHz) using the LC circuit (Cr, Lr) to reduce the switching loss and improve the conversion efficiency. An IGBT switch (H**0**) is provided as the selector switch which is turned ON in the step-down mode, and is turned OFF in the step-up mode.

The synchronous rectification circuit using MOSFET of double voltage (current doubler) full wave rectification type is provided for ensuring high output at the low voltage side. The high output is ensured by allowing a plurality of switching elements to be subjected to parallel simultaneous operation. Referring to the example shown in FIG. **2**, four elements, for example, SWA **1** to SWA **4**, SWB **1** to SWB **4** are arranged in parallel. Small reactors (L**1**, L**2**) of the switching circuit and the smoothing reactor are arranged so that two circuits are symmetrically arranged in parallel for high output. In this way, the compact reactors are provided as two-circuit arrangement so as to make the entire structure of the DC-DC converter device compact compared with the case where the single large-sized reactor is disposed. In addition, the active clamp circuit is disposed to suppress generation of surge voltage in switching for reducing the pressure resistance of the switching element. The resultant low pressure resistance of the circuit section allows the device to have the compact size. The LC filter circuit is provided for reducing the output noise of the DC-DC converter device **100**. The LC filter circuit includes a reactor L**3** and a capacitor Cf as the series circuit.

FIG. **3**(*a*) is an exploded perspective view of the DC-DC converter device **100**. FIG. **3**(*b*) is an exploded perspective view of a high voltage circuit **106**. FIG. **4**(*a*) is an exploded perspective view of an inner structure of the DC-DC converter device **100**. FIG. **4**(*b*) is a plan view showing the inside of the DC-DC converter device **100**. FIG. **4**(*c*) is a sectional view taken along line A-A of FIG. **4**(*b*) as a view seen from the arrow direction. FIG. **5** is a perspective view illustrating a low voltage substrate in the DC-DC converter device **100**.

A control circuit board **108** has a control circuit mounted thereon for controlling the switching elements provided in the low voltage circuit and the high voltage circuit. The control circuit board **108** is fixed to a protruding portion formed on the upper surface of a metallic base board **109** with a bolt and the like. The base board **109** is fixed to a plurality of support portions protruding upward from the bottom surface of the case **101** with the bolt. As a result, the control circuit board **108** is provided above heat generating sections (the main transformer **104**, an inductor element **105** and the like) disposed on the bottom surface of the case via the base board **109**.

As FIG. **3**(*a*) shows, the circuit components of the DC-DC converter device **100** are housed in the metallic case **101** (for example, aluminum die-casting). An opening of the case **101** is fitted with a case cover **102** with bolts. As described above, the case **201** of the inverter device **200** is fixed to the bottom surface side of the case **101**. The high voltage circuit **106** on which the main transformer **104**, the inductor element **105**, the switching elements H**1** to H**4** are mounted, and a low voltage circuit **107** on which the switching elements SWA **1** to SWA **4**, SAWB **1** to SWB **4** are mounted are disposed on the bottom surface inside the case. FIG. **3**(*b*) is an exploded perspective view of the high voltage circuit **106**.

In reference to the circuit diagram of FIG. **2**, the main transformer **104** correspond to a transformer Tr, and the inductor elements **105** correspond to the current doubler reactors L**1**, L**2**. The low voltage circuit board **107** includes switching elements S**1**, S**2** of the active clamp circuit shown in FIG. **2** mounted thereon.

As FIG. **5** shows, the low voltage circuit **107** has the switching elements **170** to **177** mounted on the metallic substrate on which patterns are formed. Metallic bus bars **160**, **161**, **162**, **163**, **164**, **190**, **191** are mounted on the metallic substrate.

A ferrite core **140** and a filter substrate **120** constitute an LC filter circuit disposed for reducing the output noise of the DC-DC converter device **100**. They constitute a n type LC filter circuit together with a smoothing capacitor **130** mounted on the substrate of the low voltage circuit **107**. The circuit structure is not limited to the n type LC filter circuit so long as it is intended to reduce the output noise. An output terminal **122** shown in FIG. **4**(*c*) functions as the output terminal in power conversion from the HV side to the LV side, and functions as the input terminal in power conversion from the LV side to the HV side. The converter according to this embodiment is allowed to conduct the bilateral power conversion between the HV side and the LV side. However, the converter may be configured to conduct the one-way power conversion.

A shield wall **101***a* integrated with the case **101** is formed between the LC filter circuit and the low voltage circuit section **107**. The output bus bar **162** shown in FIG. **5** bypasses the shield wall **102** to electrically couple the low voltage circuit **107**, the ferrite core **140**, the filter substrate **120** and the output terminal **122**.

The shield wall **101***a* ensures to prevent interference in the noise lessening effect of the filter owing to superimposition of the switching radiation noise on the LC filter circuit, which is caused by the switching elements of the high voltage circuit **106** and the low voltage circuit **107** although the LC filter circuit, the high voltage circuit **106** and the low voltage circuit

107 are housed in the same housing. There is no need of providing an additional housing for the LC filter circuit.

FIGS. **6**(*a*) and **6**(*b*) are perspective views each illustrating an outline of the filter substrate **120**.

A ceramic capacitor **120***a* is mounted on a substrate **120***d*, which exhibits a noise filtering function. A holding member **120***e* is a member produced by integral molding of a filter output bus bar **120***b* for electric coupling between the capacitor **120***a* and the output terminal **122**, and a GND bus bar **120***c* for electric coupling between the capacitor **120***a* and the case **101**. An insulator is interposed between the filter output bus bar **120***b* and the GND bus bar **120***c* so as to retain the insulation state. A holding member **120***e* is held and screwed to the filter substrate **120***d*.

FIG. **7** is a sectional view representing connection between the filter substrate **120** and the output terminal **122**. Arrows in the drawing represent directions of the noise current flowing through the filter circuit.

Referring to FIG. **7**, the filter output bus bar **120***b* and the GND bus bar **120***c* are adjacently disposed to face with each other. This may reduce a loop area formed by the filter output bus bar **120***b*, the filter substrate **120***d*, and the GND bus bar **120***c*. As a result, superimposition of the switching noise from the high voltage circuit **106** and the low voltage circuit **107** may be reduced.

The output terminal **122** includes a metallic section **122***a* and a mold section **122***b*. The mold section is fixed to the case **101** with a screw (not shown). Meanwhile, the film output bus bar **120***b* is fixed to the metallic section **122***a* of the output terminal **122** with a screw **150**.

The GND bus bar **120***c* is fixed to the case **101***b* with a screw (not shown).

The case **101** and the base board **109** are fixed with a screw at a connection section **109***a* via the shield wall **101***a*, which are electrically coupled with each other.

This allows the base board **109** to function as a shield for shielding the switching radiation noise from the switching element, and to bypass the noise current superimposed on the base board **109** to the case **101** before such current flows to the filter circuit section **120**.

The bus bar to which the switching noise is transmitted and the filter circuit section **120** are electrically shielded from the noise superimposed on the base board **109** caused by switching between the high voltage circuit **106** and the low voltage circuit **107**. This makes it possible to prevent the noise current from flowing to the filter circuit section **120** so as to provide sufficient filter effect. It is therefore possible to reduce the noise without lessening the filter effect.

The direct connection to the base board no longer requires connection with another component, thus providing the effect of reducing the number of components and improving productivity. Furthermore, it is possible to dispose the high voltage circuit **106**, the low voltage circuit **107**, and the filter circuit **120** in the same housing, ensuring to make the structure compact and reduce the number of components.

FIG. **8**(*a*) is a plan view showing an inner configuration of the DC-DC converter device **100**. FIG. **8**(*b*) is a sectional view taken along line B-B of FIG. **8**(*a*) as a view seen from the arrow direction.

The low voltage circuit **107** has the metallic bus bars **160**, **161**, **163**, **164** mounted on the metallic substrate. The transformer **104** includes a bus bar **180** connected to the bus bar **163** or the bus bar **164**. The transformer **104** is disposed on the bottom surface of the case **101** at the side of the low voltage circuit **107**.

The bus bars **163** and **164** are provided erect from the low voltage circuit **107** to bend toward the direction where the transformer **104** is arranged. The low voltage circuit **107** and the transformer **104** are electrically coupled by bonding the bus bar **163** or **164** to the bus bar **180**. A connection section **181** between the bus bar **163** or **164** and the bus bar **180** is formed so that an end side surface **183** of the bus bar **163** or **164** and an end side surface **182** of the bus bar **180** are laminated to face the base board **109**.

The aforementioned connection makes it possible to reduce the area of the portion where the bus bars **163**, **164**, **180** face the base board **109**. As a result, the parasitic capacitance that exists between the bus bars **163**, **164** connected to the transformer **104**, and the base board **109** may be decreased. Then it is possible to lessen superimposition of the switching noise caused by switching between the high voltage circuit **106** and the low voltage circuit **107** on the base board **109**.

The connection between the bus bars **163**, **164** and the main transformer **104** has been described with respect to the shape characteristic and the resultant effect. The connection between the bus bars **160**, **161** and the inductor element **105** is similar to the connection as described above, which is expected to provide the similar effects.

FIG. **9**(*a*) is a plan view showing an inner configuration of the DC-DC converter device **100**. FIG. **9**(*b*) is a sectional view taken along line A-A of FIG. **9**(*a*) as a view seen from the arrow direction.

The connection section **109***a* is positioned in the space between the filter circuit **120** and the ground terminal **101***c* to the ground near the outer wall of the case **101**. The aforementioned arrangement allows the noise current superimposing on the base board **109** to bypass to the ground terminal **101***c* for grounding through the shield wall **101***a* and the connection section **109***a* thereof shown as the path indicated by the arrow of FIG. **9**(*b*).

It is therefore possible to prevent transmission of the noise current superimposed on the base board **109** to the filter circuit **120**, thus ensuring lessening of external output of the noise owing to switching between the high voltage circuit **106** and the low voltage-side switching circuit section **107** from the external output terminal.

FIG. **10** is a sectional view taken along line D-D of FIG. **4**(*b*). The transformer **104** is pressed toward the bottom surface of the case **101** with the metallic board **110** so as to be fixed thereto with the screw. This makes it possible to shield the influence of the magnetic field generated by the transformer **104** with the metallic board **110** without transmission to the base board **109**. As for connection of the metallic board **110**, the main transformer **104** and the case **101** are fixed via the metallic board **110** so as to suppress backlash upon mount of the main transformer **104**, and to exhibit the anti-vibration performance in addition to the shield performance.

The aforementioned explanation is one example, and is not limited or restricted to the correlation between the description of the above embodiment and the scope of claim. For example, in the aforementioned embodiment, the power converter to be mounted on the vehicle, for example, PHEV or EV has been described as the example. The present invention is applicable to the power converter to be applied to the vehicle as construction machine without being limited to the one as described above.

In this embodiment, the power converter having the inverter and the converter integrated has been explained as the example. It is also possible to be configured to only employ the converter.

LIST OF REFERENCE SIGNS

100: converter device
101: case

101*a*: shield wall, **101***b*: case, **101***c*: ground terminal
13: inlet pipe, **14**: outlet pipe
200: inverter device, **201**: inverter case
102: case cover
104: main transformer, **104***a*, b: terminal of main transformer
105: inductor element
106: high voltage circuit, **107**: low voltage circuit,
108: control circuit board
109: base board, **109***a*: connection section
120: filter substrate, **120***a*: capacitor, **120***b*: filter output bus bar
120*c*: GND bus bar, **120***d*: substrate, **120***e*: holding member
160, **161**, **162**, **163**, **164**, **190**, **191**: bus bar on low voltage substrate
140: ferrite core
122: output terminal, **122***a*: metallic section of output terminal
122*b*: mold for output terminal
110: metallic board
H**1** to H**4**: switching element

The invention claimed is:

1. A DC-DC converter comprising:
a transformer;
a high voltage-side switching circuit section electrically disposed between the transformer and a high voltage-side circuit section;
a low voltage-side switching circuit section electrically disposed between the transformer and a low voltage-side circuit section;
a noise filter circuit section electrically disposed between the low voltage-side switching circuit section and the low voltage-side circuit section;
a metallic case that houses the transformer, the high voltage-side switching circuit section, the low voltage-side switching circuit section, and the noise filter circuit section;
a drive circuit board having a drive circuit that drives the low voltage-side switching circuit section; and
a metallic base board having the drive circuit board mounted thereon,
wherein the case has a metallic partition wall disposed in an interior portion of the case and connected to the case;
the partition wall is disposed between, and completely separates from each other, the low voltage-side switching circuit section and the noise filter circuit section; and
the partition wall is connected to the base board.

2. The DC-DC converter according to claim **1**,
wherein the base board is disposed at a position opposite a bottom surface of the case, which interpose the low voltage-side switching circuit section.

3. The DC-DC converter according to claim **1**,
wherein the low voltage-side switching circuit section includes a first bus bar;
the transformer includes a second bus bar, and the low voltage-side switching circuit section is disposed on a bottom surface of the case;
the transformer is disposed on the bottom surface of the case at a side of the low voltage-side switching circuit section;
the first bus bar is provided erect from the low voltage-side switching circuit section to bend toward a direction in which the transformer is arranged;
the low voltage-side switching circuit section and the transformer are electrically coupled by bonding the first and the second bus bars; and
a bonded section between the first and the second bus bars is formed so that an end side surface of the first bus bar and an end side surface of the second bus bar are laminated while facing the base board.

4. The DC-DC converter according to claim **1**,
wherein the case includes a ground terminal for grounding; and
a connection section between the partition wall and the base board is positioned in a space between the noise filter circuit section and the ground terminal.

5. The DC-DC converter according to claim **1**, comprising a metallic presser board that presses the transformer toward the bottom surface of the case,
wherein the presser board is disposed in a space between the base board and the transformer.

* * * * *